National Aeronautics and Space Administration

Advanced Exploration Systems

NASA Advisory Council

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NASA Headquarters

Objectives

- Advanced development of exploration systems to reduce risk, lower life cycle cost, and validate operational concepts for future human missions beyond Earth orbit.
- Demonstrate prototype systems in ground test beds, field tests, underwater tests, and ISS flight experiments.
- Pioneer innovative approaches to improve affordability and drive a rapid pace of progress.
- Infuse new technologies developed by the Space Technology Program into exploration missions.
- Pursue robotic precursor activities in collaboration with Science Mission Directorate to characterize potential destinations for human exploration.

ETD and AES Activities Focus on Enabling New Capabilities for Exploration

Human Spaceflight Architecture Team (HAT)

Mission concepts & technology priorities

Exploration Technology Development

Advanced Exploration Systems

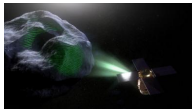
Exploration Flight Systems

Technology development

Prototype systems development

Flight systems development

Capability-Driven Architecture Elements



AES Key Capabilities

- AES builds a foundation of key capabilities to enable human and robotic exploration:
  - **Deep Space Habitation Capability**: Enable the crew to live and work safely in deep space on missions lasting over one year.
  - **Crew Mobility Capability**: Enable the crew to conduct “hands-on” surface exploration and in-space operations outside habitats and vehicles.
  - **Crew-Centered Operations Capability**: Enable more efficient mission and ground operations to improve affordability, and reduce the crew’s dependence on support from Earth.
  - **Robotic Precursors Capability**: Enable robotic precursor missions to characterize potential destinations for human exploration.

Timeline for AES Capabilities Development

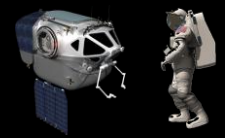
2012 2013 2014 2015 2016 2017 2018 2019 2020

- Habitat Systems
- Life Support
- Radiation Protection
- Fire Safety
- Logistics Reduction

→ Deep Space Habitation Capability

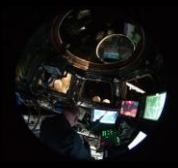
- MMSEV
- EVA
- Suitport

→ Crew Mobility Capability



- Autonomous Mission Ops
- Integrated Ground Ops
- Analog Missions

→ Crew-Centered Operations Capability



- Goldstone Radar
- RESOLVE Lunar Prospector
- Morpheus Lander / ALHAT
- RAD
- JRPA

→ Robotic Precursors Capability

AES Pioneers Innovative Approaches for Affordably Developing New Capabilities

- AES projects follow a “skunkworks-like” model for rapid development of prototype systems. Project teams are multi-disciplinary, highly collaborative, and work across organizational lines. Teams consist primarily of NASA personnel, and most of the work is performed in house.

- AES maintains critical competencies at the NASA Centers, and provides NASA personnel with opportunities to learn new skills and gain hands-on experience.

- AES leverages partnerships with external organizations to amplify investments. Partnerships include ESA for spacecraft fire safety, CSA for in-situ resource utilization, CERN for radiation sensors, and DOE for nuclear propulsion.

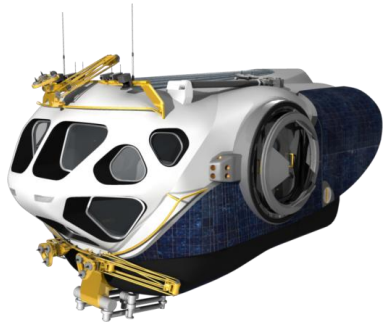
- Through NASA’s Center of Excellence for Collaborative Innovation (COECI), AES explores new models for problem solving using open innovation and crowd sourcing.
  - The NASA Tournament Lab sponsors competitions to engage the public in developing software to solve NASA challenges.
  - The COECI is working with OSTP to implement collaborative innovation across the Government.

Cycles of Innovation: Multi-Mission Space Exploration Vehicle

Prototype system development and test cycles rapidly converge on design requirements for flight systems.

Unpressurized Rover

Lunar Electric Rover



Multi-Mission Space Exploration Vehicle

AES concept demonstrators are not flight ready systems. They still need to be engineered and flight qualified for the space environment.

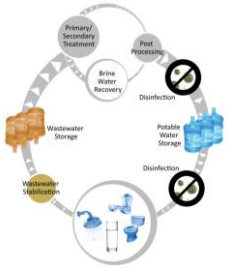
AES Projects

Crew Systems

(Lead NASA centers)

- ***Crew Mobility Systems (JSC)***: Prototype Multi-Mission Space Exploration Vehicle (MMSEV) cabin and in-space mobility chassis to enable NEO and surface exploration.

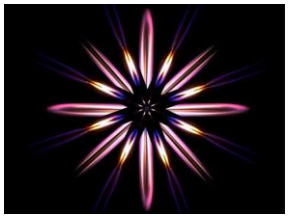
- ***Life Support Systems (MSFC, JSC)***: Improving the reliability of water recycling, air revitalization, and environmental monitoring systems using ground test beds.



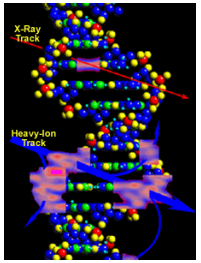
- ***EVA Systems (JSC)***: Next generation space suit, portable life support system, and suit port development leading to ISS flight demonstration.

- ***Habitation Systems (JSC)***: Deep Space Habitat concept development, systems integration, and testing.

- ***Fire Safety (GRC)***: Large-scale, in-flight fire propagation and suppression experiment using ATV.



- ***Radiation Protection (JSC)***: Integrated demonstration of radiation shielding, radiation analysis tools, and advanced dosimetry sensors.

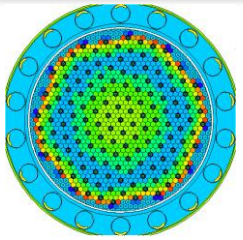


AES Projects

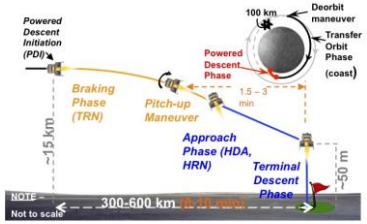
Vehicle Systems

(Lead NASA centers)

- ***Nuclear Propulsion (MSFC)***: Development of system concepts, ground test approaches, and reactor fuel elements for nuclear thermal propulsion.



- ***Autonomous Precision Landing (JSC)***: Flight test of ALHAT precision landing system on Morpheus Vertical Test Bed.



- ***Morpheus Vertical Test Bed (JSC)***: Small lander test bed for ALHAT, LOX-methane propulsion, and other vehicle systems

- ***Power Module (GRC)***: Modular batteries, fuel cells, and power systems for exploration flight systems.

AES Projects

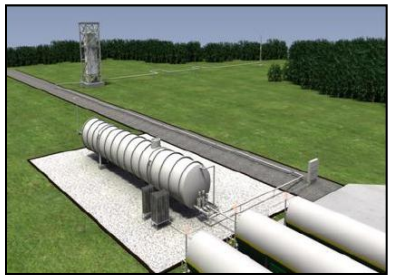
Operations

(Lead NASA centers)

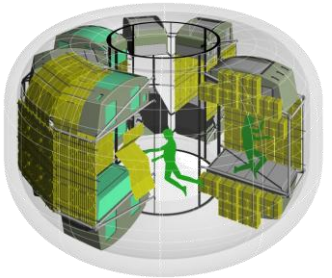
- ***Autonomous Mission Operations (ARC)***: Reducing crew dependence on ground-based mission control by automating flight dynamics and consumables management on ISS.

- ***Analogs (JSC)***: Testing prototype systems and operational concepts for NEO and Mars exploration in simulations, desert field tests, underwater environments, and ISS flight experiments.

- ***Ground Operations Systems (KSC)***: Demonstrating zero-loss cryogenic storage and intelligent systems health monitoringto reduce launch operations costs.



- ***Logistics (JSC)***: Reducing logistics storage volume and repurposing trash to reduce launch mass.



AES Projects

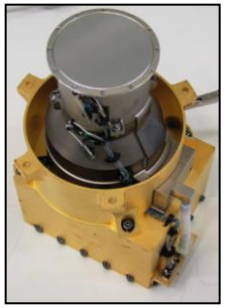
Robotic Precursor Activities

(Lead NASA centers)

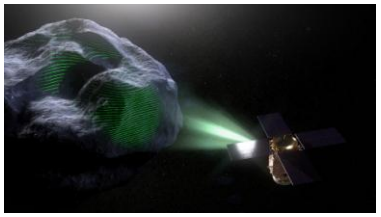
- ***Imaging Near Earth Asteroids (JPL)***: Using the Goldstone radar to image and characterize 20 NEAs at 4-meter resolution.

- ***Prospecting for Lunar Ice (KSC)***: RESOLVE in-situ resource utilization experiment to characterize lunar volatiles in partnership with Canadian Space Agency.

- ***Measuring the Mars Surface Radiation Environment (JPL)*:** Supporting operations of Radiation Assessment Detector (RAD) on Mars Science Laboratory mission.



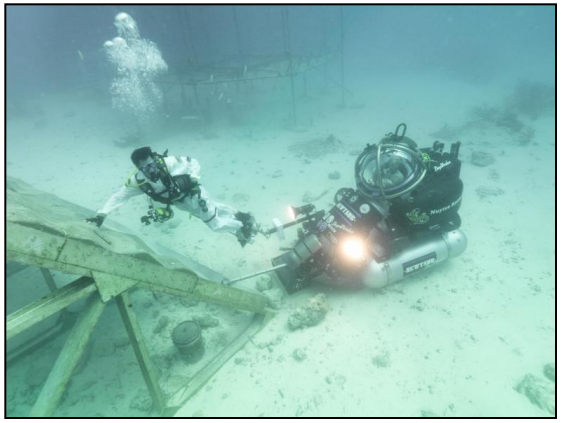
- ***Joint Robotic Precursor Activities (MSFC)*:** Partnership with Science Mission Directorate to develop instruments for missions of opportunity and acquire strategic knowledge related to potential destinations for human exploration.



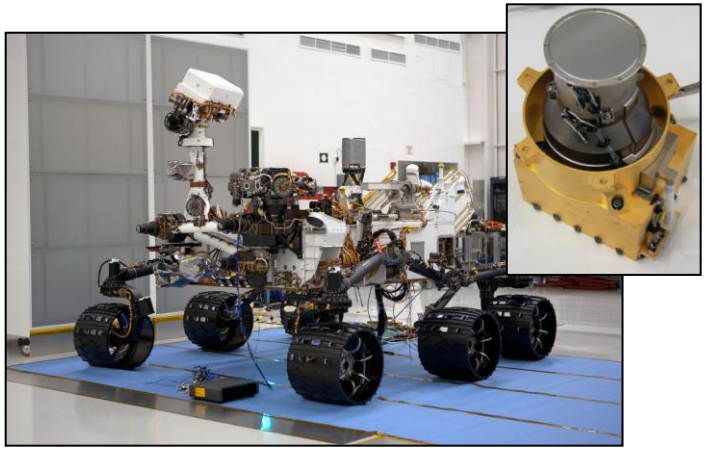
Advanced Exploration Systems

Recent Accomplishments

Multi-Mission Space Exploration Vehicle (MMSEV) project evaluated human factors of crew cabin in tests on air-bearing floor.



Analog Missions project conducted NEEMO-15 underwater test to simulate asteroid mission operations and test anchoring techniques for EVA in low gravity.



Radiation Assessment Detector (RAD) was launched on Mars Science Laboratory mission on November 25. RAD will measure Mars surface radiation environment.

Goldstone Radar project has imaged five near-Earth asteroids to determine their size, shape, and spin rate.

Summary

- The AES Program is pioneering new approaches for rapidly developing prototype systems, demonstrating key capabilities, and validating operational concepts for future human missions beyond Earth orbit.

- AES is exploring innovative approaches to rapidly develop and test prototype systems, and make missions more affordable.

- ISS is a key stepping stone for enabling deep space exploration. Many AES projects will evolve into larger integrated systems and mission elements that will be tested on ISS before we venture beyond Earth orbit.

- AES will incorporate new technologies developed by the OCT Space Technology Program.

- AES is implementing streamlined management practices to drive a rapid pace of progress, and use limited resources more effectively.